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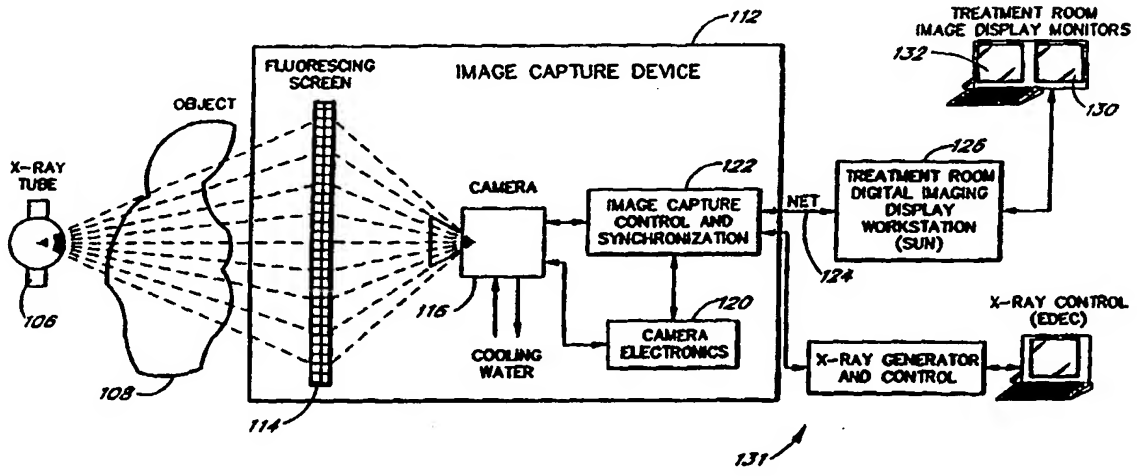

(57) Abstract

A proton beam digital imaging system comprising an X–ray source which is movable into the treatment beam line that can produce an X–ray beam through a region of the patient. An X–ray receiver receives the X–ray beam after it has passed through the patient and the X–ray receiver generates photons that correspond to the X–ray image. The photons are directed to a TEC CCD camera to produce a patient orientation image which displays the orientation of the center of the beam relative to selected monuments in the patient's skeletal structure. The system also receives a master prescription image which displays the target isocenter with respect to the same selected monuments of the patient's skeletal structure. By comparison of the relative positions of the center of the beam in the patient orientation image and the isocenter in the master prescription image with respect to the selected monuments, the amount and direction of movement of the patient to make the beam center correspond to the target isocenter is determined.

PROTON BEAM DIGITAL IMAGING SYSTEM

Background of the Invention

Field of the Invention

The present invention relates to particle beam therapy systems and, in particular, concerns a digital imaging system for imaging a target region of a patient's body to determine the position of the patient relative to a particle beam delivery system to thereby allow the position of the patient to be adjusted into a desired position.

Description of the Related Art

Radiation particle therapy is commonly used to treat localized forms of cancer as well as other afflictions. Typically, an atomic particle, e.g., an electron, a proton, a neutron, or a sub-atomic particle, such as an X-ray, is emitted out of a nozzle towards a particular target region of the patient, often referred to as a target isocenter. The particle then collides with the cells within the target region of the patient and thereby damages these cells.

One particularly useful form of radiation therapy is proton beam therapy wherein protons are directed at a target isocenter located within a patient's body. Proton therapy has the advantage of the protons exhibiting a phenomena known as a Bragg peak wherein a substantial portion of the energy of the proton is released as the proton comes to a stop. Hence, by selecting the starting energy of the proton beam, the protons in the beam can be directed to come to a stop at the target isocenter thereby delivering a significant portion of their energy to the cells within the target isocenter. Proton therapy is currently in use at the Loma Linda University Medical Center located in Loma Linda, California, and the system used at the Loma Linda University Medical Center is described in greater detail in U.S. Patent No. 4,870,287.

While proton therapy has significant clinical advantages over other types of therapy in particular instances, it also requires that the patient be accurately positioned with respect to the nozzle of the proton beam so that the proton beam is irradiating only the target isocenter. Otherwise, the proton beam could damage healthy cells within the patient's body. This is particularly important, for example, in treatments wherein the target isocenter is located within the brain of the patient. While accurately locating the patient with respect to a nozzle is very important in proton therapy, it is, of course, also very important in many other types of radiation therapy for similar reasons.

Typically, the patient who is receiving the proton therapy receives periodic treatments wherein the target isocenter is irradiated with the proton beam repeatedly over the course of an extended time period. For example, a patient may receive daily doses of proton radiation therapy over a month long period. Further, the target isocenter is often irradiated with a proton beam from a variety of different angles when the proton beam is delivered via a gantry system, such as the gantry system described in U.S. Patent No. 4,917,344 and U.S. Patent No. 5,039,057.

To ensure that the patient is accurately positioned with respect to the nozzle of the proton therapy beam, the position of the target isocenter is initially determined with respect to one or more monuments within the body of the patient. Generally, the monuments are comprised of points on the skeletal structure of the patient and the location of the target isocenter is then determined with respect to these monuments. One technique for determining the position of the target isocenter is to use a digitally reconstructed radiograph (DRR). Specifically, CT scans of the patients are taken using well-known techniques. These are assembled into the DRR and the location of the

determination. Further, this system should also be readily adaptable into a gantry system wherein the determination of the patient's body with respect to the nozzle can be performed regardless of the angular orientation of the nozzle about the patient.

Summary of the Invention

The aforementioned needs are satisfied by the proton therapy system of the present invention which comprises a gantry, a nozzle that is positioned on the gantry from which a proton beam will emerge, a beam path which feeds the proton beam to the nozzle, a moveable X-ray source which can be positioned in the beam path and an X-ray receiver positioned so as to receive X-rays that have been produced by the X-ray source after these X-rays have passed through the patient. Preferably, both the X-ray source and the X-ray receiver are mounted on the gantry so that the X-ray source and the X-ray receiver can be used to produce an image of the region of the patient that is in the path of the proton beam regardless of the orientation of the nozzle with respect to the patient. Further, the X-ray receiver preferably produces a digital image of the region of the patient that is in front of the nozzle.

In one aspect of the invention, the system also includes a computer system which has one or more master prescription images of the target isocenter and several landmarks or monuments within the body of the patient. In the preferred embodiment, the master prescription image is produced using a Digitally Reconstructed Radiograph (DRR) and the prescribing physician can determine the location of the target isocenter with respect to one or more preselected monuments within the body of the patient. The digital X-ray image produced by the image receiver preferably shows the center of the beam superimposed against the skeletal structure of the patient. The landmarks or monuments that have been selected in the master prescription image are preferably landmarks on the skeletal structure which are also perceivable in the X-ray image. The system preferably allows the treating physician to identify the monuments on the X-ray image and then determine the spatial relation between the center of the beam to the monument. The spatial relation of the center of the beam with regards to the monuments is then compared to the spatial relation between the target isocenter and the very same monuments in the prescription master image. This comparison yields offset values which are indicative of how far the center of the beam is offset from the target isocenter within the patient. These values can then be used to move the patient so that the target isocenter is correctly oriented in the center of the beam.

Preferably, there is a master prescription image prepared for each of the angles of the gantry that the beam is to be directed at the patient. Since the X-ray source and X-ray receiver are attached to the gantry, the positioning image can be obtained whenever the gantry is moved to a new position and the offsets can be appropriately calculated.

In another aspect of the invention, the X-ray receiver is comprised of an apparatus that includes a fluorescing screen, which fluoresces in response to X-rays impinging on the screen, wherein the photons generated by the fluorescing screen are then directed along a compact path to a cooled digital capture device. In one embodiment the digital capture device is comprised of a CCD camera having a 512 x 512 pixel thinned CCD sensor with an attached thermal electric cooler. The cooler removes heat energy and thereby reduces the amount of noise produced by the camera so that the camera is capable of obtaining an X-ray image of the portion of the patient's

from the photons. The camera 116 is cooled in a manner that will be described in greater detail hereinbelow to approximately -30° C to remove excess heat and to thereby eliminate noise in the image produced by the camera. The camera 116 is controlled by control electronics 120 and by control and synchronization logic 122 so that the shutter of the camera 116 opens in response to the X-ray tube 106 transmitting the X-rays and then captures the image which can then be provided via a net 124 to a treatment room digital imaging display workstation 126.

The treatment room digital imaging display workstation 126 produces a display on a monitor 130 of the digital image that was captured by the camera 116. Further, the treatment room digital imaging display workstation 126 receives master prescription images of the patient 108 which are simultaneously displayed on a monitor 132 in the treatment room.

As will be described in greater detail in reference to Figures 6 and 7 hereinbelow, the imaging system 100 of the preferred embodiment obtains a digital image of the region of the patient's body that is positioned along the path of the beam for a given position of the gantry and then displays this image on the monitor 130. The system 100 also receives a prescription master image of the patient's body, wherein a target isocenter has been defined with respect to various monuments or landmarks within the patient's body. This master prescription image displays the portion of the patient's body containing the target isocenter from the same perspective on the monitor 132, i.e., the same gantry angle, as the X-ray image that is simultaneously being displayed on the monitor 130. The treating physician then has to identify the monuments or landmarks in the X-ray image on the monitor 130 that correspond to the monuments and landmarks in the master prescription image on the monitor 132 and the treatment room digital imaging display workstation 126 then determines the spatial relation between the center of the beam in the X-ray image on the monitor 130 with the target isocenter displayed on the monitor 132. This spatial relation can then be used to move the patient in an appropriate fashion so that the patient is positioned in front of the nozzle so that the beam path intersects the target isocenter.

Figure 2 illustrates a preferred embodiment of the beam delivery system 102, which incorporates the imaging system 100, in greater detail. Specifically, the beam delivery system 102 includes a gantry described above which rotates about a center point 140. The beam delivery system 102 includes a snout 110 where the proton beam is emitted. Preferably, the snout is mounted on a ring (not shown) of the gantry so that the snout rotates about the center point 140. The X-ray source 106 is mounted to the beam delivery system 102 so as to be rotatable about the center point 140. Similarly, the image capture device 112 is also mounted on the ring at a position opposite the X-ray source 106 (Figure 3) so as to be centered about the beam path 146 in all the angular orientations of the beam delivery system. In Figure 2, the gantry 104 is positioned so that the snout would emit a beam along a beam path 146 that corresponds to an x-axis 151. It will be appreciated, however, that the snout 110 can be moved so that the beam path 146 extends in a different direction but still intersects the center point 140. The beam delivery system 102 also includes a treatment table 150 that is moveable along a z-axis 152 and the X-ray source 106.

The patient 108 is positioned in a pod 149, such as the pod disclosed in U.S. Patent No. 4,905,267 which is hereby incorporated by reference, and the pod 149 and patient 108 are then positioned on the treatment table

Hence, the X-ray source 106 and the image capture device 112 are capable of producing an image of the portion of the patient 108 that is positioned in front of the nozzle of the beam delivery system 102 in every orientation of the gantry 104. It will be appreciated that the image capture device 112 has to be mounted to the ring 144 of the gantry in a manner where the image capture device 112 will remain in the beam path 146 throughout the whole range of motion of the gantry 104. Hence, the supports 162a and 162b, as well as the enclosure 160, are made of a sufficiently rigid material so that the image capture device 112 does not move with respect to the snout 110 throughout the whole range of motion of the gantry.

Figures 5A - 5E illustrate the image capture device 112 in greater detail. Specifically, Figure 5A shows the enclosure 160 of the image capture device 112 with the outer walls 170 of the enclosure partially broken away to show the components positioned therein. In the preferred embodiment, the enclosure is comprised of a frame 172 with a plurality of panels 174 bolted to the frame 172 in such a manner that the interior of the enclosure 160 is dark. It will be understood from the following discussion that the image capture device 112 must produce an accurate, undistorted digital image of the portion of the body of the patent 108 that is positioned in front of the snout 110, i.e., along the beam path 146, from X-rays produced by the X-ray source 106. Hence, the enclosure 160 must be constructed so that no additional light is introduced into the enclosure other than the light occurring as a result of X-rays impinging upon the image capture device 112 in the manner described below.

Figures 5B and 5C illustrate a side view and a front side 176 of the image capture enclosure 160, respectively. The front side 176 is the side which is facing the X-ray source 106 and is perpendicular to the beam path 146 (Figure 2) when the image capture device 112 is mounted to the gantry 104 in the manner shown in Figure 2. A square aperture or entry port 182 (Figure 5C) is formed in the left-hand side of the front side 176 of the enclosure 160. In the preferred embodiment, there is a protective cover 184, a radiographic grid slot 186 and an X-ray cassette slot 190 positioned in front of the entry port 182. Further, there is a fluorescing screen assembly 192 (Figure 5A) that is positioned immediately behind the X-ray cassette slot 190 so as to be positioned immediately adjacent the entry port 182 of the enclosure 160.

As shown in Figure 5C, three cross-wires 200a-200c are formed in the protective cover so as to intersect at a point which is in the center of the entry port 182. As will be described hereinbelow, the cross-wires 200a-200c provide a visual indication to a treating physician as to the position of the center of the X-rays propagating down the beam path 146 relative to monuments within the body of the patient 108. Hence, the intersection of the cross-wires 200a-200c is preferably located at the exact center of the beam path 146. This requires the enclosure 160 of the image capture device 112 to be exactly located with respect to the snout 110.

In the preferred embodiment, the radiographic grid slot 186 and the X-ray cassette slot 190 are both capable of receiving a radiographic grid 187 and an X-ray cassette 191 (Figure 5A). Hence, patient alignment can also be performed using the prior art technique of obtaining photographic X-ray images of the position of the patient. Hence, the patient alignment system of the preferred embodiment allows for both alignment using digital images and alignment using photographic images.

image produced by the image capture device 112. The baffles 204 are positioned so that substantially all of the light that is incident upon the lens 216 of the camera 116 is travelling in a line that is parallel to the preferred path 203 of the light in the enclosure 160. Hence, light that emanates from the fluorescing screen assembly 192 at an angle to the path 203, is preferably absorbed or reflected multiple times so that it does not reach the lens 216. In this manner, noise in any resulting digital image is reduced.

Preferably, the camera 116 is mounted to the interior of the image capture device enclosure 160 on a mount that allows for adjustment about a horizontal, vertical and longitudinal axis. Further, the mount should also allow for angular adjustment about an optical axis 214 which is defined as the path of the photons from the mirror to the lens. This allows for the camera to be oriented in an optimum position for receiving the image produced by the X-rays impinging on the fluorescent screen assembly 192. Further, the camera 116 is configured to produce an image based upon the low levels of light produced by the X-rays impinging on the fluorescing screen assembly 192.

In the preferred embodiment, the camera is a CCD camera that has 512 x 512 active pixels with a 100% fill factor, the objective field size of the camera is 355.6mm x 355.6mm wherein the pixels are .69mm square. Preferably, the camera is a thermally electric cooled (TEC) CCD type camera with liquid recirculation that removes the TEC generated heat. In the preferred embodiment, the camera is a model MCD 1000S scientific grade CCD camera available from Spectral Source, Inc. of Westlake Village, CA. The lens 216 is preferably comprised of a F.95 lens with a 50mm focal length.

As shown in Figures 5D and 5E, the camera 116 is water cooled through a pair of cooling hoses 230 that provide water to the camera 116 and remove heated water from the camera 116. The cooling hoses 230 in the preferred embodiment are interconnected with a water supply (not shown) which is a component of the gantry assembly 104. The water cooling system cools the CCD camera so that the CCD camera is maintained at a -30°C temperature. This cooling of the camera 116 ensures that the camera 116 will be able to produce a visual digital image that corresponds to an X-ray image of the portion of the patient 108 that is positioned in front of the snout 110 of the beam delivery system 102.

Figure 6 is a flow chart which illustrates the operation of the system 100 to determine the position of the patient 108 relative the snout 110 of the beam delivery system 102. Specifically, from a start state 400, a prescription for the patient is then generated in state 402 using well-known techniques. Typically, the prescription is based upon the physician determining the location, characteristics, and size of the portion of the patient's body to be treated. For example, if the treatment consists of applying radiation treatment to a tumor, the prescription will be based upon the size, characteristics and location of the tumor. The prescription will include such information as the radiation dose to be delivered to the tumor, the frequency of the radiation dose, and the angles that the radiation dose will be delivered to the patient from the gantry. This prescription is typically generated using well-known dosimetry techniques.

Further, a digitally reconstructed radiograph (DRR) is also developed for the patient in state 404 using well-known techniques. Specifically, in the preferred embodiment, DRR files are created using a DRR application using

Once the master prescription image 500 of the patient 108 has been developed, complete with the selection of the monuments and the determination of the vector coordinates of the target isocenter relative the monuments, this information can then be provided to the digital imaging system 100 and used for subsequent treatments of the patient 108. Specifically, in state 412, the patient can then be positioned on the treatment table 150 (Figure 2) and the gantry 104 can then be rotated to a desired treatment angle. As discussed above, the patient 108 is preferably substantially immobilized within the pod and the pod is positioned on the treatment table 150 in a fixed orientation relative the snout 110 of the beam delivery system 102. Typically, the patient is positioned within the pod and the pod is positioned on the table 110 so that the pod is generally aligned with the snout 110 of the beam delivery system 102. Subsequently, the X-ray source 106, is positioned within the beam line 146 in state 414 in the manner described in reference to Figure 3 and, in state 416, the X-ray source is initiated so that X-rays emanate out of the snout 110 of the beam delivery system 102, through the portion of the patient's body that is located immediately in front of the snout 110 and to the image capture device 112. This results in an image 500' of the portion of the patient's body that is located immediately in front of the snout 110 of the beam delivery system 102 being generated and displayed by the workstation 126 or the display 130 (Figure 1).

An exemplary captured X-ray image 500' is shown in Figure 7B. This image consists primarily of the skeletal structure 510' of the patient 108 in the region that is in front of the snout 110 with the cross-wires 200a-200c (Figure 5C) superimposed on the image. It will be appreciated that the cross-wires interrupt X-rays that are directed towards the fluorescing screen assembly 192 (Figures 5A and 5B) which thereby results in fewer photons being generated in the region of the cross-wires. Preferably, the cross-wires 200a-200c are positioned so that they intersect in the direct geographic center of the beam path 146. Further, there may in fact be a second set of cross-wires positioned in the beam line located adjacent the snout 110 of the beam delivery system 102 so that the two sets of cross-wires can be used for alignment verification. For example, misalignment between the two sets of cross-wires will indicate that the image capture system 102 is no longer centered about the beam path 146 which will inform the operator of the gantry system 102 to take the necessary corrective action.

Once the X-ray image 500' of the patient 108 in the beam path 146 has been captured by the image capture system 112, the image 500' is fed to the treatment room digital imaging display workstation 126 (Figure 1) and is then displayed on the treatment room image display monitor 130. Further, the master prescription image 500 is also simultaneously displayed on the monitor 132 in state 420. This allows the treating physician to simultaneously view the master prescription image 500 of Figure 7A and the X-ray image 500' of Figure 7B. Subsequently, the treating physician can then, in state 422, select monuments 506' and 508' on the X-ray image 500' that correspond to the monuments 506 and 508 on the master prescription image 500. Preferably, the treating physician selects these images by using a mouse and clicking on the monuments shown on the X-ray image.

Once the monuments 506', 508' have been selected on the X-ray image 500' that correspond to the monuments 506 and 508 selected on the master prescription image 500, the workstation 126, in state 424, then determines the coordinates of the monuments 506' and 508' (X_1', Y_1') and (X_2', Y_2'), respectively, on the X-ray image with respect to the beam center 512. As explained above, the beam path center 512 is indicated by the intersection

Hence, the digital imaging system of the preferred embodiment provides for more efficient alignment of the patient with the beam nozzle. Specifically, the treating physician simply has to position the patient in the pod in front of the nozzle and the iteratively determine the relative position between the beam path and the target isocenter relative to selected monuments within the patient's body. This eliminates the need for producing photographic X-ray images of the portion of the patient's body in front of the nozzle and also allows for automatic calculation of the offset between the beam path center and the target isocenter. Consequently, patient alignment is simplified and is more efficient which allows for greater use of the treatment facility.

Although the foregoing description of the preferred embodiment of the present invention has shown, described and pointed out the fundamental novel features of the invention, it will be understood that various omissions, substitutions and changes in the form of the detail of the apparatus as illustrated, as well as the uses thereof, may be made by those skilled in the art without departing from the spirit of the present invention. Consequently, the scope of the invention should not be limited to the foregoing discussion, but should be defined by the appended claims.

6. The system of Claim 5, wherein said receiver and said CCD camera are positioned in an enclosure wherein said receiver is positioned within an aperture of said enclosure that is centered about said beam path and wherein said enclosure defines a path for said photons produced by said receiver which directs said photons to said CCD camera.

7. The system of Claim 6, wherein said enclosure includes two mirrors so that said photons emanating from said fluorescing screen travel in a first direction towards one of said mirrors, are reflected in a second direction towards a second mirror and are then reflected in a third direction, which is generally parallel to said first direction, towards said CCD camera.

8. The system of Claim 7, wherein said enclosure includes one or more baffles to prevent at least a portion of any photons which are travelling in a direction that has a component transverse to the directions of said path from reaching said CCD camera.

9. The system of Claim 8, wherein said X-ray source is comprised of a diagnostic quality X-ray tube that operates in the 30kV - 150kV energy range, the fluorescing screen is comprised of a square of gadolinium sulphur dioxide and the CCD camera includes a thinned CCD sensor that is 512 by 512 pixels and said CCD camera includes a F.95 lens with a 50 mm focal length.

10. The system of Claim 9, wherein said CCD camera receives said photons directly from said fluorescing screen in said path so that said patient orientation image is substantially undistorted by intensification.

11. The system of Claim 4, further comprising a pair of cross-wires attached to said receiver so as to be centered in said beam path, wherein said cross-wires interrupt said X-rays from said X-ray source so that fewer photons are produced by said fluorescing screen in the region of said cross-wires which results in an image of said cross-wires appearing on said patient orientation image.

12. The system of Claim 1, further comprising:

a first monitor which receives signals from said controller and displays said master prescription image; and

a second monitor which receives signals from said controller and displays said patient orientation image wherein a treating physician can manipulate said controller so as to designate said one or more rigid structures on said patient orientation image.

13. The system of Claim 1, wherein said controller performs a least squares approximation to determine the offset between the center of the beam line and the isocenter relative said one or more rigid structures and wherein said one or more rigid structures comprise monuments on said patient's skeletal structure.

14. An imaging system for a proton beam therapy system having a proton source, a beam delivery system with a nozzle that is mounted on a gantry so that said proton beam can be delivered to the patient from a plurality of angles, wherein said imaging system receives a master prescription image of a region of the patient that is to be treated, said imaging system comprising:

an X-ray source mounted on said beam delivery system wherein said X-ray source is movable between a first position, wherein said source can project an X-ray beam along a treatment beam path

19. The system of Claim 18, wherein said image capture device is comprised of a CCD camera that receives said photons produced by said fluorescing screen and thereby produces said patient orientation image.

20. The system of Claim 19, wherein said CCD camera is water cooled so as to remove excess noise from said patient orientation image.

21. The system of Claim 20, wherein said receiver and said CCD camera are positioned in an enclosure wherein said receiver is positioned within an aperture of said enclosure that is centered about said beam path and wherein said enclosure defines a path for said photons produced by said receiver which directs said photons to said CCD camera.

22. The system of Claim 21, wherein said enclosure includes two mirrors so that said photons emanating from said fluorescing screen travel in a first direction towards one of said mirrors, are reflected in a second direction towards a second mirror and are then reflected in a third direction, which is generally parallel to said first direction, towards said CCD camera.

23. The system of Claim 22, wherein said enclosure includes one or more baffles to prevent photons which are travelling in a direction that has a component transverse to the direction of said path from reaching said CCD camera.

24. The system of Claim 23, wherein said X-ray source is comprised of a diagnostic quality X-ray tube that operates in the 30kV - 150kV energy range, the fluorescing screen is comprised of a square of gadolinium sulphur dioxide and the CCD camera includes a thinned CCD sensor that is 512 by 512 pixels and said CCD camera includes a F.95 lens with a 50 mm focal length.

25. A method of aligning a patient in a proton beam therapy system so that the center of the beam line is centered at a target isocenter positioned within the body of the patient, said method comprising the steps of:

obtaining a master prescription image of the patient for a desired orientation of the beam wherein the master prescription image is stored in a computer system;

positioning the patient on a treatment table so that the region of the patient's body containing the target isocenter is positioned in front of the nozzle;

transmitting an imaging beam along the treatment beam path so that the imaging beam is transmitted into the region of the patient's body positioned in front of the nozzle;

receiving the imaging beam after it has been transmitted into the region of the patient's body and capturing a patient orientation image of the region of the patient's body that is positioned in said beam path that is provided to said computer system;

designating said one or more monuments, using said computer system, on said master prescription image;

designating said one or more monuments, using said computer system, on said patient orientation image wherein said one or more monuments designated on both said master prescription image and said patient orientation image correspond to the same point of said patient's anatomy;

calculating the relative location between the selected monument in the patient orientation image and the center of said beam line.

32. The method of Claim 25, wherein the step of determining the distance and direction the patient will have to be moved comprises performing a least squares fit between the relative location of the target isocenter with respect to said one or more monuments of the master prescription image and the relative location of the center of the beam path with respect to said one or more monuments.

33. A therapeutic imaging system for a treatment beam therapy system having a treatment beam source, a beam delivery system with a nozzle that is configured to provide the treatment beam from a plurality of different angles, said therapeutic imaging system comprising:

an X-ray beam source mounted on said beam delivery system wherein said X-ray beam source is movable between a first position, wherein said X-ray source can project an X-ray beam along a treatment beam path towards a first side of said patient, and a second position wherein said X-ray is removed from said beam path to thereby allow said treatment beam to travel along said treatment beam path;

a fluorescing screen positioned so as to be centered about said beam path wherein said fluorescing screen receives said X-ray beam after it has passed through a region of the patient that is positioned in said beam path and produces a resulting photon image; and

a digital camera which receives said photon image directly from said fluorescing screen and produces a patient orientation image of the region of the patient's body that is positioned in said beam path so that said patient orientation image is substantially undistorted by intensification.

34. The system of Claim 33, wherein said therapeutic imaging system is configured to be used with a proton beam therapy system having a proton source, a beam delivery system with a nozzle that is mounted on a gantry so that said proton beam can be delivered to the patient from a plurality of angles and wherein said therapeutic imaging system is capable of producing said patient orientation image over a plurality of orientations of said gantry;

35. The system of Claim 34, further comprising a controller which receives a master prescription image of a region of a patient that is to be treated and said patient orientation image wherein said controller is configured so that one or more monuments can be designated on said master prescription image so as to define the relative position of an isocenter to be treated in the patient's body with respect to said one or more monuments.

36. The system of Claim 35, wherein said controller is also configured so that said one or more monuments can be designated on said patient orientation image so that said controller can determine the relative location of the center of said beam line with respect to said one or more monuments and wherein said controller using said relative positions of said target isocenter and said beam line center with respect to said one or more monuments determines the relative movement between the patient and the nozzle required so that the position of the center of the beam line with respect to the one or more monuments corresponds to the position of the target isocenter with respect to said one or more monuments.

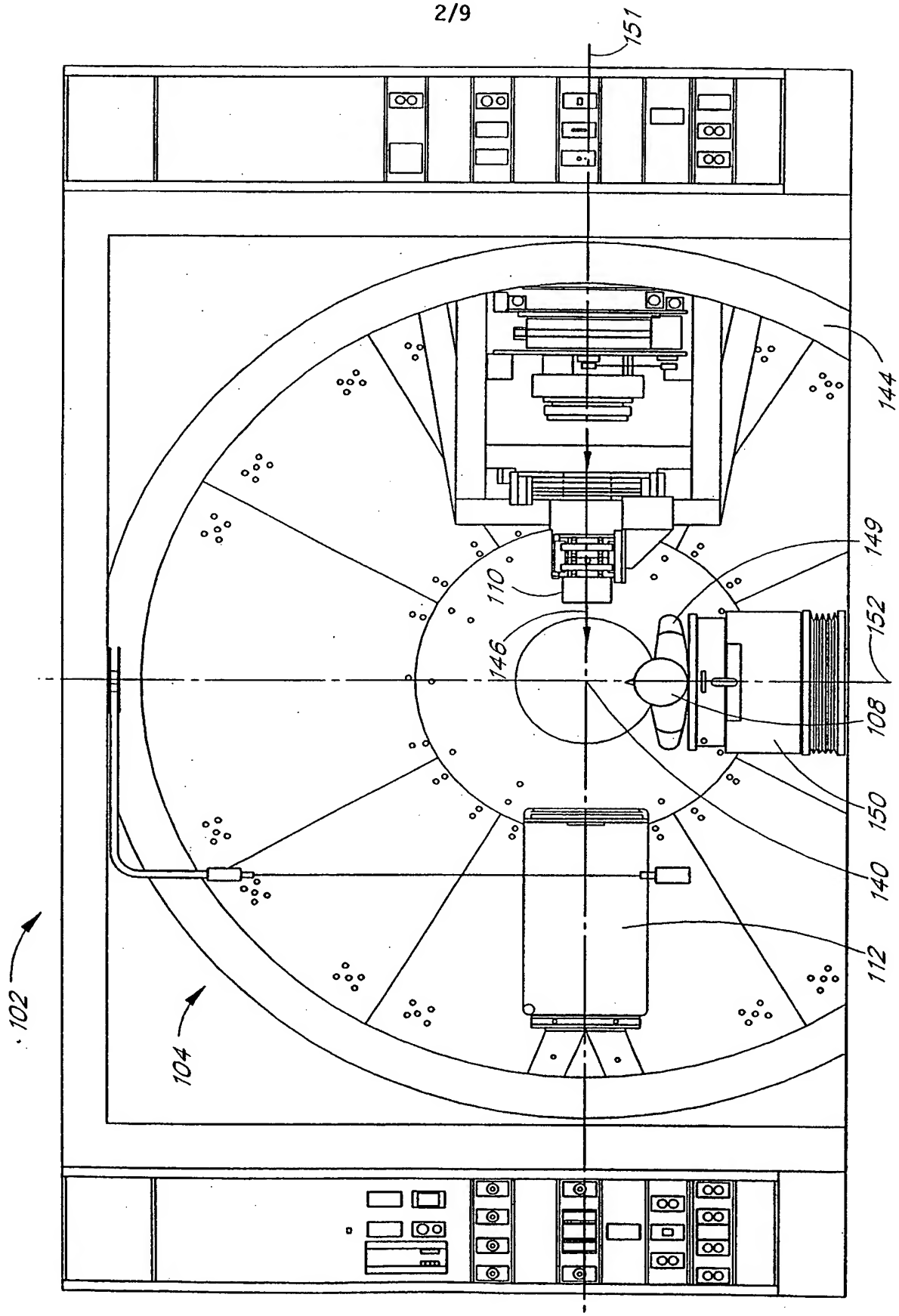

FIG. 2

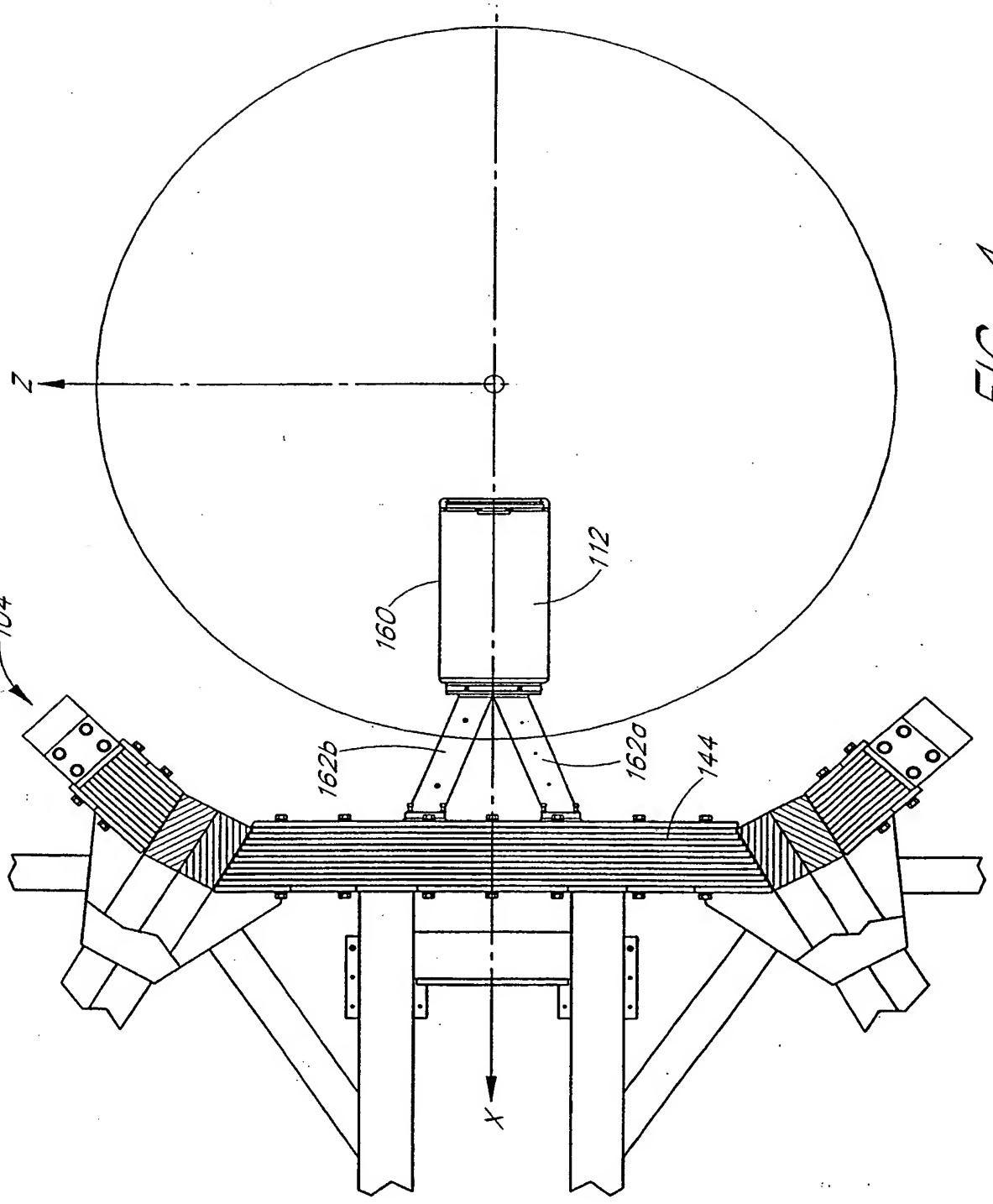

FIG. 4

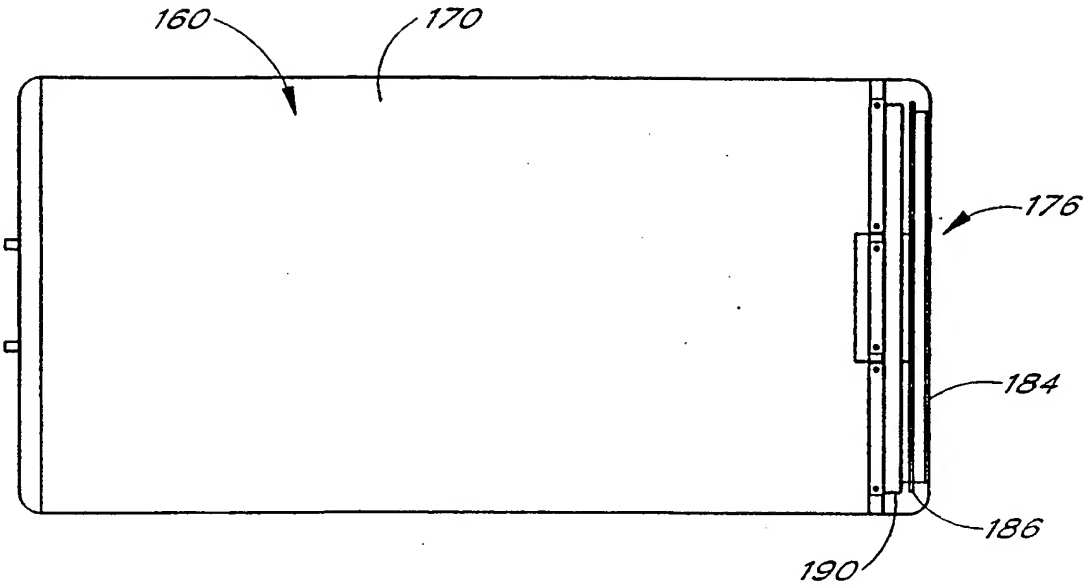

FIG. 5B

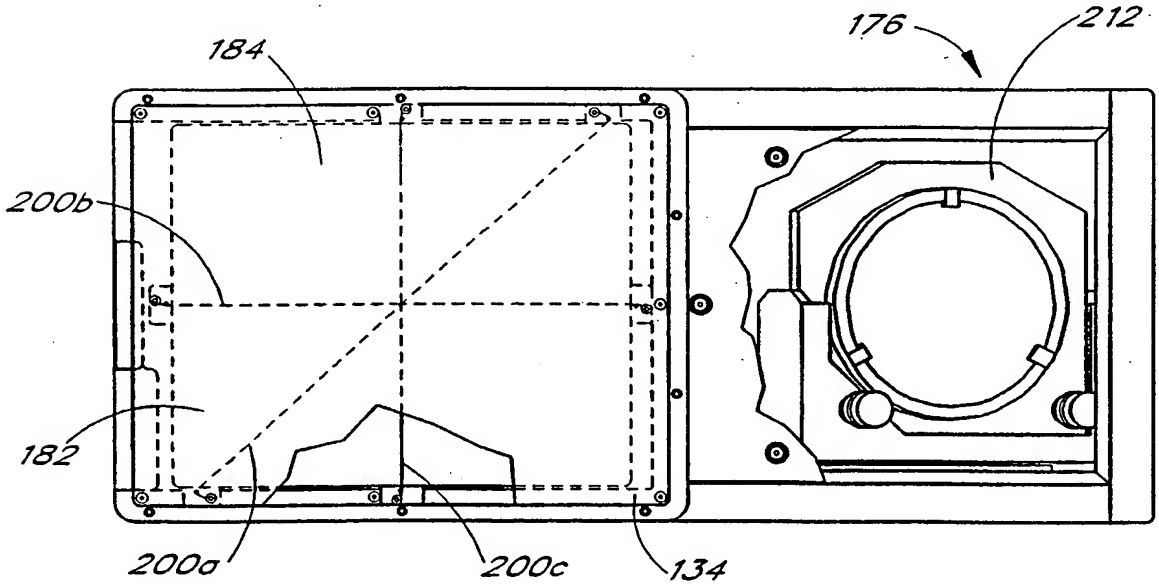

FIG. 5C

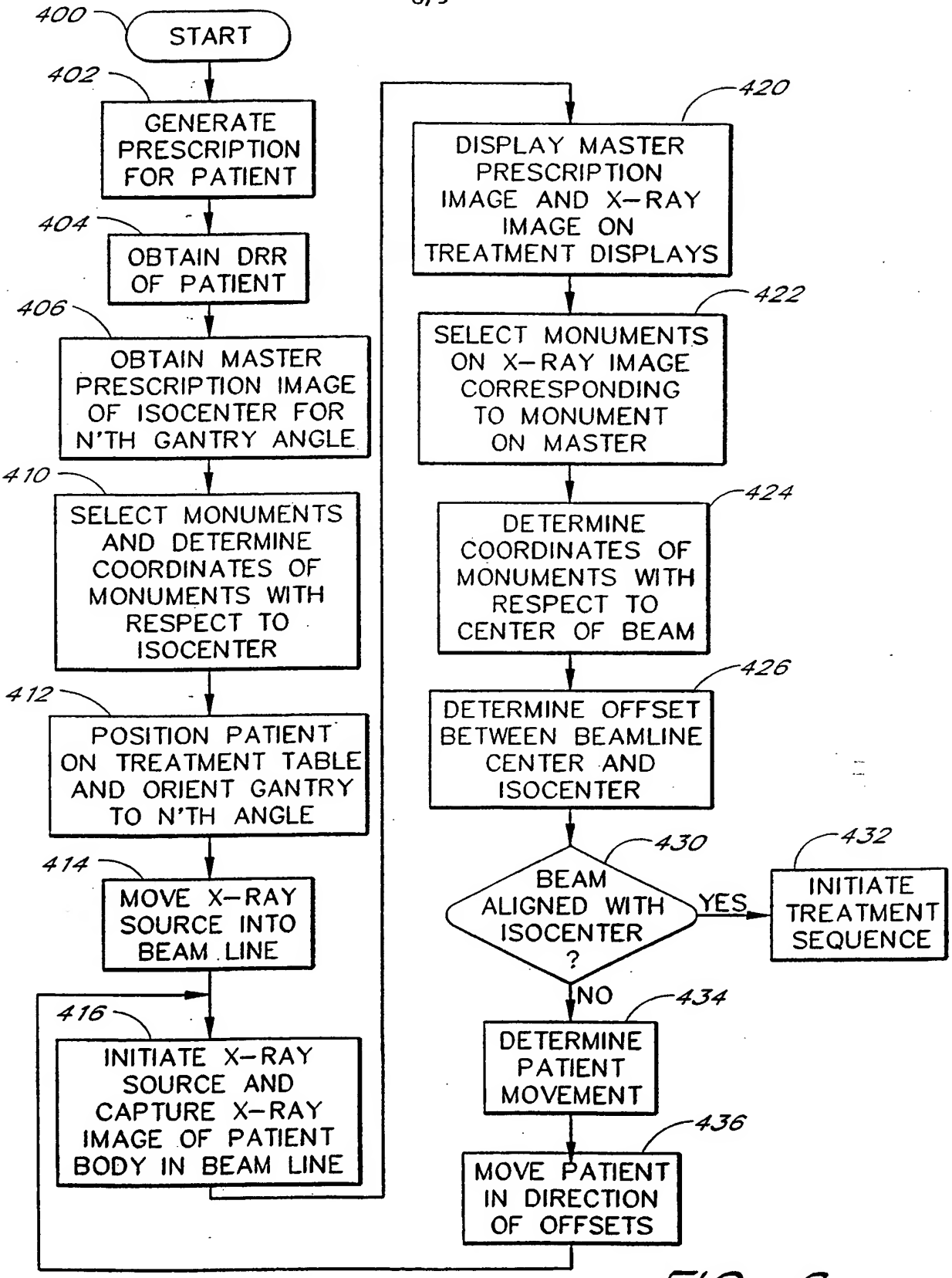

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/19236

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61N5/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	EP 0 480 035 A (YOKOGAWA MEDICAL SYSTEMS) 15 April 1992 see abstract; claim 1 ---	1,14,25, 33
A	EP 0 673 661 A (TOSHIBA) 27 September 1995 see abstract see column 16, line 20 - column 20, line 10 --- -/--	1,14,25, 33

[X] Further documents are listed in the continuation of box C

[X] Patent family members are listed in annex.

Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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3

Date of the actual completion of the international search	Date of mailing of the international search report
5 February 1998	13/02/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl. Fax: (+31-70) 340-3016	Taccoen, J-F

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 97/19236

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